

2009 BFRL Project Description

Project Title: Metrics and Tools for Construction Productivity

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BFRL Program: Construction Integration and Automation Technologies

Objective: To develop the metrics, tools, and data for measuring construction productivity at three levels: (1) task; (2) project; and (3) industry.

Problem:

What is the problem? Although the construction industry is a major sector of the U.S. economy, it has experienced a prolonged period of decline in productivity. Due to the critical lack of measurement methods, however, the magnitude of the productivity problem in the construction industry is largely unknown. To address these deficiencies, efforts are underway to measure construction productivity at three levels: task, project, and industry. ***Tasks*** refer to specific construction activities such as concrete placement or structural steel erection. ***Projects*** are the collection of tasks required for the construction of a new facility (e.g., the construction of a new commercial office building) or renovation (i.e., additions, alterations, and major replacements) of an existing constructed facility. ***Industry*** measures are based on the North American Industrial Classification System (NAICS) codes for the construction sector and represent the total portfolio of projects. Producing measures of construction productivity at each level involves the development of both metrics and tools. Once produced, these metrics and tools will help construction industry stakeholders make more cost-effective investments in productivity enhancing technologies and improved life-cycle construction processes; they will also provide stakeholders with new measurement and evaluation capabilities.

Why is it hard to solve? Developing project level metrics is hard because of the many different tasks that must be rolled up to produce a single representative productivity measure. Overall, measuring construction productivity is hard because on the one hand construction industry stakeholders, such as building owners and managers, want easy answers to complicated questions that are made available through task-level metrics, while, on the other hand, industry leaders, policy makers at the federal and state levels, construction industry researchers/academics, and Bureau of Labor Statistics (BLS) industry specialists demand complicated data-intensive metrics to assess national and industry-wide trends and challenges facing this critical sector of the U.S. economy.

How is it solved today, and by whom? The problem is not solved today. There are currently neither project-level nor industry-level measures of productivity for the U.S. construction industry, although limited efforts aimed at this problem are underway in Canada¹ and within the European Union.^{2, 3} Construction productivity metrics published by the Construction Industry Institute (CII) and RS Means tend to focus on measuring task productivity. Unfortunately, the current practice for producing these metrics suffers from two serious shortcomings. First, the published task level productivity metrics do not address changes in technology. Second, they do not include any means for identifying improvement opportunities.

Why NIST? The project relates directly to BFRL's mission to promote U.S. competitiveness in that measures of productivity help managers identify where productivity, and therefore competitiveness, can be improved. It also directly supports the BFRL vision of our becoming the source of critical solution-enabling tools, in this case improved productivity metrics. The project directly supports the strategic goal of "Measurement Science for Breakthrough Improvements in Construction Productivity," and it aligns with BFRL's core competency "Information, Communication and Automation Technologies for Intelligent Integration of Building Design, Construction and Operation." Because of BFRL's unique expertise, experience, and work ties with ASTM, CII, and BLS, we are uniquely positioned to play this leadership role in the development and implementation of improved metrics.

Approach:

What is the new technical idea? BFRL, working in collaboration with CII, has identified how to incorporate improvement opportunities and to address changes in technology in the development of task-level metrics. BFRL researchers have identified two promising metrics for producing a project productivity index. The first is patterned after Teicholz's seminal paper on construction productivity.⁴ The second employs a weighting system developed by BLS.⁵ At a higher level, BLS publishes two common measures of productivity—(single factor) labor productivity and multifactor productivity—useful in estimating an industry-level index. BFRL economists have reviewed the BLS metrics (both single factor and multifactor) and the data types used in the manufacturing sector. Based on that review, BFRL has identified a process through which industry-level metrics could, in theory, be generated for each construction industry NAICS code.

Why can we succeed now? The extraordinary national response to BFRL's critical analysis of the costs of inadequate interoperability in the U.S. capital facilities industry⁶ demonstrated the

¹ Canadian Construction Innovation Council, *Measuring the Performance of the Canadian Construction Industry*, Ottawa, Ontario, Canada, March 2007.

² Crawford, P. and Vogl, B., "Measuring Productivity in the Construction Industry," *Building Research & Information*, Vol. 34, Issue 3, June 2006.

³ European Communities, *The Construction Industry in the European Union*, Luxembourg, July 2005.

⁴ Teicholz, P., "Labor Productivity Declines in the Construction Industry: Causes and Remedies." *AECbytes Viewpoint*. Issue 4. April 14, 2004.

⁵ Bureau of Labor Statistics, "Chapter 11. Industry Productivity Measure," *BLS Handbook of Methods*, Washington, DC, 1997.

⁶ Gallaher, M., O'Connor, A., Dettbarn, J., and Gilday, L., *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*, NIST GCR 04-867, Gaithersburg, MD, August 2004.

breadth of our potential market constituency. Industry leaders, policy makers at the federal and state levels, construction industry researchers/academics and BLS industry specialists are today seeking sophisticated, defensible, data-intensive metrics to assess national and industry-wide trends and challenges facing the construction industry. This need is regarded as critical because construction is lagging other sectors in productivity. BFRL has the staff capability and industry connections to develop and facilitate through the standardization process implementation of these metrics.

What is the research plan? BFRL, working in collaboration with construction industry experts, will develop a draft ASTM Standard Practice on how to measure task-level productivity. At the October 2008 meeting of ASTM Subcommittee E06.81, we will outline the proposed standard and seek approval to move forward with its development. Following approval, we will work with industry experts to draft terminology for the standard, initiate the ballot process for key terms, and by the end of the fiscal year produce a draft standard practice suitable for submission to ASTM for balloting.

BFRL, working in collaboration with CII, will develop baseline measures of construction productivity at the task and project levels. The current practice used to report task productivity will be enhanced to produce a metric that, while familiar to industry proponents, will have new capabilities for tracking changes in task productivity over time. BFRL/CII will then produce two sets of project-level metrics based on: (1) a systematic task weighting procedure and (2) a modified Teicholz procedure. BFRL will partner with CII to publish baseline measures for both sets of metrics using information contained in CII's benchmarking productivity database.

BFRL will use the baseline measures and data on project cost, schedule, and field rework to identify tasks and processes (e.g., automated assembly, materials tracking) as targets for breakthrough improvements in construction productivity. BFRL will partner with CII to measure how combinations of industry best practices and automation and integration technologies impact task and project productivity. BFRL and CII will jointly publish these results to demonstrate the economic merits of productivity-enhancing practices and technologies. BFRL will collaborate with CII on the production of an archival journal article describing task- and project-level metrics. BFRL, in collaboration with the Bureau of Labor Statistics, will explore ways to use single and multifactor productivity approaches to produce industry-level metrics for construction industry NAICS codes (e.g., steel erection). Multifactor productivity metrics enable separable estimates of the contribution of labor, capital, and technology. BFRL will produce an article on how to use macroeconomic data to measure productivity in the construction industry and submit it to an archival journal. The publication of industry-level metrics by 2013 will motivate firms to implement new technologies and processes, thereby stimulating breakthrough improvements in construction productivity.

Recent Results: The Principal Investigator described the proposed approach for producing task-level and project-level productivity metrics at the fall CII Board of Advisors Meeting and received approval to work with the Benchmarking and Metrics Program to produce the metrics. Chapman and Butry produced a White Paper, *Measuring and Improving the Productivity of the U.S. Construction Industry: Issues, Challenges, and Opportunities*, and submitted it to the Board on Infrastructure and the Constructed Environment (BICE) at The National Academies. The

white paper is intended as a framing document for a Fall 2008 workshop hosted by BICE/The National Academies.

Output: Chapman, R.E., and D.T. Butry. “Measuring and Improving the Productivity of the U.S. Construction Industry: Issues, Challenges, and Opportunities.” April 2008. White Paper.

Output: Chapman, R.E., and D.T. Butry. “Measuring and Improving the Productivity of the U.S. Construction Industry: Issues, Challenges, and Opportunities.” Presented to the Board on Infrastructure and the Constructed Environment at The National Academies. Washington D.C. July 2008.

Output: Kang, Y., W.J. O’Brien, S.R. Thomas, and R.E. Chapman. (*In Press*). “Impact of Information Technologies on Performance: A Cross Study Comparison.” *Construction Engineering and Management*.

Outcome: Developed approach for producing task-level and project-level productivity metrics.

Standards and Codes: Improved metrics will increase the rate of investment in productivity enhancing technologies, including information, communication, and automation technologies, conveying benefits on individuals, businesses, and government in the form of lower costs of building services and products. The mechanism for getting these standard metrics into practice is to write draft standards for balloting by the ASTM Subcommittee on Building Economics.

Impact: Industry adoption and use of ASTM Standard Practice for measuring task-level productivity.

Impact: Increased rate of investment in productivity enhancing technologies by building owners and contractors.